--CROSS-REFERENCE TO RELATED APPLICATIONS

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This application is a continuation-in-part of U.S. Patent Application No. 08/966,797, filed November 10, 1997 and issued January 25, 2000 as U.S. Patent No. 6,018,065.--

In the Claims:

Please amend claims 1, 7, 23, 47 and 51-54 as follows:

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1. (twice amended) A method for removing from a microelectronic device structure a noble metal residue including at least one metal selected from the group consisting of platinum, palladium, iridium and rhodium, the method comprising contacting the microelectronic device structure with a gas-phase reactive halide composition comprising a halide component selected from the group consisting of SF_6, SiF_4, Si_2F_6, SiF_2 radical, SiF_3 radical, and XeF_2, wherein the halide component is present in an amount effective to remove [the] sufficient residue from the microelectronic device structure to reduce noble residue-caused deficiencies in the operation of the microelectronic device.

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4 7. (twice amended) A method according to claim 6, wherein the pressure of the cleaning gas is from about 50 mTorr to about 2 Torr, and [the each fill of] the cleaning gas is maintained in the chamber for a period of time which is from about 10 seconds to about 10 min.

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23. (twice amended) The method according to claim 22 wherein the agent further comprises an iridium halide species selected from the group consisting of $Ir(X)_1$, $Ir(X)_3$, $Ir(X)_4$ and $Ir(X)_6$, wherein X represents the halide of the reactive halide composition.

24. (twice amended) The method according to claim 19, wherein:

(a) the [cleaning gas] gas-phase reactive halide composition further comprises a gas phase reactive halide species selected from the group consisting of SF_6, SiF_4, Si_2F_6, SiF_2 radical and SiF_3 radical; and

(b) the microelectronic device structure is further contacted with an agent to assist in volatilizing and removing the noble metal residue on the microelectronic device structure.

47. (twice amended) The method according to claim 41, wherein the microelectronic device structure is disposed in a chamber, and the [gas phase XeF_2] cleaning gas is continually flowed through the chamber, in combination with an energetic dissociation source.

51. [The method according to claim 1,] A method for removing from a microelectronic device structure a noble metal residue including at least one metal selected from the group consisting of platinum, palladium, iridium and rhodium, the method comprising contacting the microelectronic device structure with a gas-phase reactive halide composition comprising a halide component selected from the group consisting of SF_6, SiF_4, Si_2F_6, SiF_2 radical, SiF_3 radical, and XeF_2, to remove the residue, wherein the reactive halide composition comprises SiF_4.

52. [The method according to claim 1,] A method for removing from a microelectronic device structure a noble metal residue including at least one metal selected from the group consisting of platinum, palladium, iridium and rhodium, the method comprising contacting the microelectronic device structure with a gas-phase reactive halide composition comprising a halide component selected from the group consisting of SF_6, SiF_4, Si_2F_6, SiF_2 radical, SiF_3 radical, and XeF_2, to remove the residue, wherein the reactive halide composition comprises Si_2F_6.

53. [The method according to claim 1,] A method for removing from a microelectronic device structure a noble metal residue including at least one metal selected from the group consisting of platinum, palladium, iridium and rhodium, the method comprising contacting the microelectronic device structure with a gas-phase reactive halide composition comprising a halide component selected from the group consisting of SF_6, SiF_4, Si_2F_6, SiF_2 radical, SiF_3 radical, and XeF_2, to remove the residue, wherein the microelectronic device structure is disposed in a chamber, said method further comprising:

(a) evacuating the chamber;

(b) filling the chamber with a cleaning gas comprising the reactive halide composition; and

(c) retaining the reactive halide composition in the chamber to react with the residue; and

(d) sequentially repeating said steps of filling and evacuating to effect removal of the noble metal residue from the microelectronic device structure.

54. (amended) A method for removing from a microelectronic device structure a noble metal residue comprising at least one metal selected from the group consisting of platinum, palladium, iridium and rhodium, the method comprising contacting the microelectronic device structure with a gas-phase reactive halide composition comprising a halide component selected from the group consisting of SF_6, SiF_4, Si_2F_6, SiF_2 radical, SiF_3 radical, and XeF_2, wherein the halide component is present in an amount and for a time sufficient to remove [the] sufficient residue to reduce residue-caused deficiencies in the operation of the microelectronic device structure.

Add the following new claims 57-60:

57. A method for removing from a microelectronic device structure a noble metal residue including at least one metal selected from the group consisting of platinum, palladium, iridium and rhodium, the method comprising contacting the microelectronic device structure with a gas-phase reactive halide composition comprising a halide component selected from the group consisting of SF_6, SiF_4, Si_2F_6, SiF_2 radical, SiF_3 radical, and XeF_2, in an amount effective to at least partially remove the residue.

58. A method for removing from a microelectronic device structure a noble metal residue including at least one metal selected from the group consisting of platinum, palladium, iridium and rhodium, the method comprising contacting the microelectronic device structure with a gas-phase reactive halide composition:

(a) comprising a halide component selected from the group consisting of SF_6, SiF_4, Si_2F_6, SiF_2 radical, SiF_3 radical, and XeF_2, in an amount effective to at least partially remove the residue; and

(b) lacking a nitrogen- or phosphorous-containing π-acceptor ligand.

59. A method for removing from a microelectronic device structure a noble metal residue including at least one metal selected from the group consisting of platinum, palladium, iridium and rhodium, the method comprising contacting the microelectronic device structure with a gas-phase reactive halide composition consisting essentially of a halide component selected from the group consisting of SF_6, SiF_4, Si_2F_6, SiF_2 radical, SiF_3 radical, and XeF_2, in an amount effective to at least partially remove the residue, and optionally including:

(a) an agent selected from the group consisting of Lewis bases and electron back-bonding species; and/or

(b) selected from the group consisting of carbon monoxide, trifluorophosphine, and trialkylphosphines.

60. A method for removing from a microelectronic device structure a noble metal residue including at least one metal selected from the group consisting of platinum, palladium, iridium and rhodium, the method comprising contacting the microelectronic device structure with a gas-phase reactive halide composition comprising a halide component selected from the group consisting of SF_6, SiF_4, Si_2F_6, SiF_2 radical, SiF_3 radical, and XeF_2, wherein the halide component is present in an amount effective to remove sufficient residue from the microelectronic device structure to eliminate noble residue-caused deficiencies in the operation of the microelectronic device.

REMARKS

1. Satisfaction of Definiteness Requirement of 35 U.S.C. § 112, Second Paragraph

The Examiner has rejected claims 1, 7, 23, 24, 47, 49, 50 and 54 under 25 U.S.C. § 112, as indefinite.

1.1 Definiteness of Claims 1 and 54

The Examiner takes two incompatible and contradictory positions with regard to the limitation "amount effective to remove the residue." On one hand the Examiner argues in paragraph 11 of the Office Action that the phrase is indefinite because: "one of ordinary skill in the art would not be reasonably apprised of the scope of the invention."

On the other hand, in paragraph 26 of the Office Action the Examiner takes the position that use of an "amount effective to remove the residue" is inherent in the teachings of Ashby, since "the alternative (i.e., using an amount that is ineffective to remove the residue) is *not consistent with that which is expected from a skilled artisan*" (emphasis added).

Thus, the Examiner maintains the position that **the limitation is so unclear that it cannot be understood by one of skill in the art**, while at the same time maintaining the position that **the limitation is so basic to the understanding of one of skill in the art that it must be viewed as an inherent teaching of the cited reference**.

In fact, the limitation is so basic that it is readily understood by the skilled artisan in view of the teachings of the specification.[1] The specification describes the residue-caused deficiencies in microelectronic device structures that are overcome by the claimed invention.[2] The skilled artisan would readily understand that the limitation entails sufficient cleaning to at least partially overcome the problems associated with the residue.

Nevertheless, in spite of the clarity of the term, in order to expedite the allowance of the application, claim 1 is amended to recite:

> wherein the halide component is present in an amount effective to remove sufficient residue from the microelectronic device structure to reduce noble residue-caused deficiencies in the operation of the microelectronic device.

Similarly, claim 54 is amended to recite:

> wherein the halide component is present in an amount and for a time sufficient to remove sufficient residue to reduce residue-caused deficiencies in the operation of the microelectronic device structure.

These amendments overcome the stated 35 U.S.C. § 112, second paragraph, rejections of claims 1 and 54.

1.2 Definiteness of Claims 7, 23 and 47

Claim 7 is amended to remove the phrase "the each fill of."

As suggested by the Examiner, claim 23 is amended to recite "wherein the agent further comprises."

The Examiner suggests that the term "the cleaning gas" in claim 47 has no antecedent basis. The term "the cleaning gas" was actually not present in claim 47 as amended by the January 10, 2000 Amendment.

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[1] "A decision on whether a claim is invalid under § 112, 2d P, requires a determination of whether those skilled in the art would understand what is claimed when the claim is read in light of the specification...." *Orthokinetics, Inc. v. Safety Travel Chairs, Inc.*, 806 F.2d 1565, 1576 (Fed.Cir. 1986).

[2] See the specification at page 3, first paragraph.

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However, by amendment presented herein, the term is added to the claim; it finds clear antecedent basis in claim 41, from which it depends, which recites (emphasis added):

> A method for removing from a microelectronic device structure a noble metal residue comprising iridium, the method comprising contacting the microelectronic device structure with **a cleaning gas** comprising gas-phase XeF_2 to at least partially remove the noble metal residue.

1.3 Rejection of Cancelled Claim 50

The Examiner objects to the term "the gas phase reactive halide composition" recited in claim 50. However, claim 50 was cancelled by the January 10, 2000 Amendment; consequently, this rejection is moot.

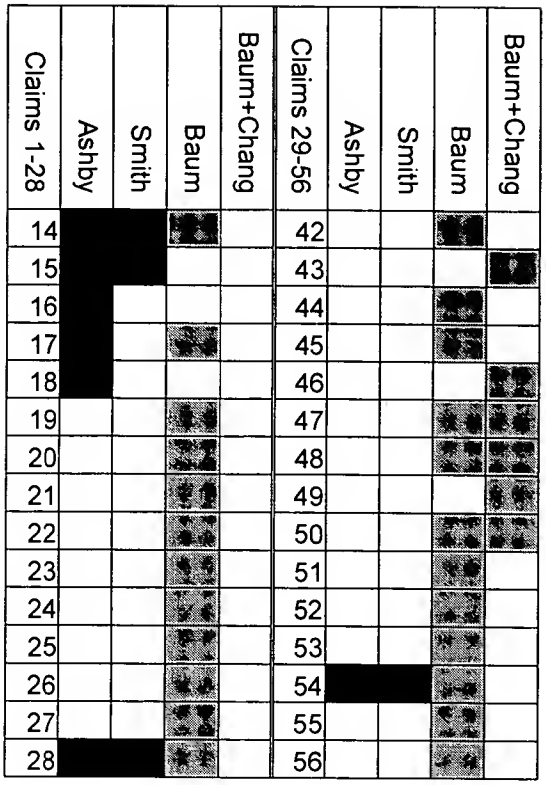
1.4 Conclusion

Based on the foregoing arguments and amendments, all 35 U.S.C. § 112, second paragraph rejections are overcome, and the Examiner is respectfully requested to withdraw such rejections.

2. Novelty and Nonobviousness of the Pending Claims

The art-based rejections set forth in the April 12, 2000 Office Action are summarized in the following spreadsheet:

Claims 1-28	Ashby	Smith	Baum	Baum+Chang	Claims 29-56	Ashby	Smith	Baum	Baum+Chang
1	■	■	▒	▒	29	■		▒	
2		■	▒		30	■	■	▒	
3	■	■	▒		31	■	■	▒	
4	■	■	▒		32	■		▒	
5	■		▒		33	■	■	▒	
6	■	■	■		34	■		■	
7	■	■	■		35	■		■	
8	■	■	▒	▒	36	■		▒	
9	■	■	▒		37	■		▒	
10		■	▒		38	■		▒	
11		■	▒		39	■		▒	
12		■		▒	40	■		▒	
13	■	■	▒		41			■	▒



The *light* shaded areas indicate rejections which are rendered moot by the amendment of the application to claim priority to Baum et. al. (U.S. Patent 6,018,065), with the result that no art-based rejections remain for claims 19-27, 41-53 and 55-56. These claims are therefore free of prior art.

2.1 Claims 19-27, 41-53 and 55-56 Free of Prior Art

Claim 19 is an independent claim, and claims 20-23 depend from claim 19. Accordingly, claims 19-27 are in condition for allowance.

Claims 51, 52 and 53, as pending prior to the entry of this amendment, depended from claim 1. These claims are revised by incorporating the limitations of claim 1, there by rendering them *independent* claims. These claims are also in condition for allowance.

Claims 55-56 are also independent claims. In the absence of any valid prior art being cited against these claims, they are plainly novel and nonobvious and are in condition for allowance.

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2.2 Ashby et al., U.S. Patent 5,814,238,

The Examiner has entered 35 U.S.C. § 102 rejections (claims 1, 3-6, 8, 9, 13-18, 28-33, 54) and 35 U.S.C. § ~~102~~ 103 rejections (claims 1, 7, 33-40) based on Ashby et al.

Ashby et al. teaches away from the claimed invention. "A reference may be said to teach away when a person of ordinary skill, upon reading the reference, would be **discouraged from following the path set out in the reference**, or would be **led in a direction divergent from the path that was taken by the applicant**."[3]

A person of skill in the art would learn from Ashby et al. that an intermediary reactant species (such as a SF_6) is **useful only when used in addition to** the nitrogen- or phosphorous-containing π-acceptor ligand.[4]

Consequently, a person of ordinary skill would be discouraged by Ashby et al. from attempts to utilize the intermediary reactant species in an amount sufficient to remove sufficient residue to reduce residue-caused deficiencies in the operation of the microelectronic device structure.

As discussed in the January 10, 2000 Amendment, Ashby et al. does not teach the use of SF_6 as a cleaning agent, but as an "intermediary reactant species" for use with a class of etching agents termed "π-acceptor ligands":

> According to the present invention, the exposed portion [of a transition metal thin film, defined by openings in a masking layer over the thin film,] may be removed by providing **at least one nitrogen- or phosphorous-containing π-acceptor ligand** in proximity to the transition metal thin film and dry etching the transition metal thin film and forming a volatile complex comprising the nitrogen- or phosphorous-containing π-acceptor ligand and the transition metal.[5]

Ashby et al. describes the use of the intermediary reactant species as follows:

> In some preferred embodiments of the present invention, **an intermediary reactant species** (such as a halide ligand and/or a carbonyl ligand) may be provided **in addition to the nitrogen- or phosphorous-containing π-acceptor ligand**, with the intermediary species forming an **intermediary reaction product** or complex with the transition metal **prior to a further chemical reaction** with the nitrogen- or phosphorous-containing π-acceptor ligand for forming **a final reaction product comprising a volatile transition metal/π-acceptor ligand complex**.[6]

[3] *In re Gurley*, 31 U.S.P.Q.2d 1130, 1131 (Fed. Cir. 1994).
[4] Ashby et al. at column 4, lines 50-53.
[5] Ashby et al., U.S. Patent 5,814,238, column 4, lines 43-58.
[6] Ashby et al., U.S. Patent 5,814,238, column 4, lines 43-58.

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The Examiner argues that the intermediary reactant species (i.e., the halide compound) is inherently present in Ashby "in an amount effective to remove the residue." However, Ashby et al. specifically teaches otherwise. If the Examiner's contention were correct, then the nitrogen- or phosphorous-containing π-acceptor ligand would not be necessary in Ashby et al. Yet, the the nitrogen- or phosphorous-containing π-acceptor ligand is described by Ashby et al. as essential ("**at least one** nitrogen- or phosphorous-containing π-acceptor ligand") to the volatilization of the transition metal.

The intermediary reactant species of Ashby et al. are therefore clearly not present "in an amount sufficient to remove sufficient residue to reduce residue-caused deficiencies in the operation of the microelectronic device structure," as is required of the halide species enumerated in claim 1. The intermediary reactant species of Ashby et al. are not described by Ashby et al. as being present in an amount effective to remove anything. Instead, they are described as:

> forming an intermediary reaction product or complex with the transition metal **prior to a further chemical reaction** with the nitrogen- or phosphorous-containing π-acceptor ligand for forming a final reaction product comprising a volatile transition metal/π-acceptor ligand complex.

Thus the sequence described by Ashby et al. is as follows: (1) forming an intermediary reaction product with a transition metal; (2) the occurrence of a **further** chemical reaction with the nitrogen- or phosphorous-containing π-acceptor; leading to (3) a **final reaction product** comprising a volatile transition metal/π-acceptor ligand complex.

Ashby et al. teaches that it is only the **final reaction product**, not the **intermediate reaction product**, which is volatile.

2.3 Smith et al. U.S. Patent 5,911,887

The Examiner rejected claims 1-4, 6, 8, 12-15, 28, 30, 31, 33, and 54, under 35 U.S.C. § 102, and 7 and 9-11 based on 35 U.S.C. § 103, based on Smith et al.

The Examiner contends that Smith et al. teaches the use of XeF_x and SF_6 as reactive halides. However, Smith et al. teaches using these species only for etching "an anti-reflective coating/etch stop layer of **titanium-tungsten alloy**" not for ething a material selected from the group consisting of "**platinum, palladium, iridium and rhodium**" as required by claim 1. The full text of the section referenced by the Examiner is as follows:

> [W]hen an anti-reflective coating/etch stop layer of **titanium-tungsten alloy** overlies a layer of aluminum as a conductive material layer, the etchant species used to etch the anti-reflective coating/etch stop layer is preferably a chemical species which does not contain carbon, examples of which include Cl_2, HF, HCl, SOF_2, SOF_4, SF_2, SO_2F_2, SF_4, PF_3, PF_5, POF_3, PCl_3, $POCl_3$, PCl_5, BF_3, BrF, AsF_3, AsF_5, HBF_4, SbF_5, $XeF_{[x]}$and SF_6, preferably SF_6.[7]

One of skill in the art would not know from this teaching whether XeF_x and SF_6 are suitable for cleaning "**platinum, palladium, iridium and rhodium**" from the surface of a microelectronic device structure, as required by claim 1.

It must be emphasized that to demonstrate anticipation, the Examiner bears the burden of identifying a single prior art reference that "discloses **each and every limitation** of the claim."[8] **If even one element is missing from the prior art, there can be no finding of anticipation.**[9] In other words, **anticipation under §102(a) requires that the identical invention that is claimed was previously known to others and thus is not new.**[10]

A teaching that SF_2 and $XeF_{[x]}$ can be used to **etch titanium-tungsten alloy** does not anticipate a claim reciting the use of these species for **cleaning platinum, palladium, iridium and rhodium** from the surface of a microelectronic device structure.

Claims 2-4, 6, 8, 12-15, 28, 30, 31, 33, and 54 depend from claim 1, for from claims which depend from claim 1, and are novel and nonobvious, *inter alia*, on the same bases as claim 1.

Additionally, the parameters recited in claims 7 and 9-11 are not a matter of the mere optimization of a process taught in Smith et al., since Smith et al., teaches an etching process while the applicants recite a cleaning process. Moreover, as noted above, Smith et al. teaches the use of XeF_x and SF_6 for **etching titanium-tungsten alloy**, and not for **cleaning platinum, palladium, iridium and rhodium**, as required by the applicants' claim 1, from which claims 7 and 9-11 depend.

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[7] Smith et al., column 5, lines 53-60.
[8] *Glaxo Inc. v. Novopharm Ltd.*, 52 F.3d 1043, 1047 (Fed. Cir.) (emphasis added), cert. denied, 116 S. Ct. 516 (1995) (emphasis added).
[9] *Kalman v. Kimberly-Clark Corporation*, 713 F.2d 760, 772 (Fed. Cir. 1983), cert. denied, 465 U.S. 1026 (1984).
[10] *Continental Can Co. USA, Inc., v. Monsanto Co.*, 948 F.2d 1264, 1267 (Fed. Cir. 1991).

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2.4 Baum et al. U.S. Patent 6,018,065

The Examiner has rejected claims 1-7, 10, 11, 13, 14, 17, 19-42, 44, 45 and 51-56 under 35 U.S.C. § 102, and claims 1, 8, 9, 41, 47, 48 and 50 under 35 U.S.C. § 103, based on Baum et al.

By amendment presented herein, the applicants have revised the application to claim priority to Baum et al., thereby removing Baum et al. as prior art.

2.5 Baum et al. U.S. Patent 6,018,065 and Chang et al. Proc. of SPIE Reference, 1995.

The Examiner has rejected claims 1, 8, 12, 41, 43 and 46-50 based on Baum et al., in view of Chang et al. However, as noted above, the application is revised to claim priority to Baum et al., thereby removing Baum et al. as prior art. Accordingly this rejection is rendered moot.

2.6 Conclusion

Based on the amendments presented herein, and the arguments set forth above, all art-based rejections have been overcome and the application is in condition for allowance.

3. New Claims

New claim 57 is added to recite the specific aspect of the applicants' invention in which the halide component is provided in an amount effective to **at least partially remove** the residue.

New claim 58 is added to recite the specific aspect of the applicants' invention in which the gas-phase reactive halide composition **lacks a nitrogen- or phosphorous-containing π-acceptor ligand**.

New claim 59 is added to recite the specific aspect of the applicants' invention in which the gas-phase reactive halide composition **consists essentially of** a halide component selected from the group consisting of SF_6, SiF_4, Si_2F_6, SiF_2 radical, SiF_3 radical, and XeF_2, and optionally includes an agent selected from the group consisting of Lewis bases and electron back-bonding species and/or an agent selected from the group consisting of carbon monoxide, trifluorophosphine, and trialkylphosphines.

New claim 60 is added to recite the specific aspect of the applicants' invention in which the halide component is present in an amount effective to remove sufficient residue from the microelectronic device structure to **eliminate** noble residue-caused deficiencies in the operation of the microelectronic device.